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A Comparison of Training Procedures on the Emergence of Multiply Controlled Tacts

By

Mary E. Halbur, M.S.

A Dissertation submitted to the Faculty of the Graduate School,
Marquette University,
in Partial Fulfillment of the Requirements for
the Degree of Doctor of Philosophy

Milwaukee, Wisconsin

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ABSTRACT
A COMPARISON OF TRAINING PROCEDURES ON THE EMERGENCE OF
MULTIPLY CONTROLLED TACTS

Mary E. Halbur, M.S.

Marquette University, 2020

Vocal exchanges are comprised of responses under multiple sources of stimulus control. For example, a picture may contain multiple components, and an instructor may ask a learner to respond differentially to questions about the picture (e.g., “who,” “what,” “where,” “color,” “number,” “shape”). Children with autism spectrum disorder frequently have difficulty acquiring these types of verbal conditional discriminations. For example, the format of training may affect the development of verbal behavior under multiple sources of stimulus control. Therefore, the present investigation compared training stimuli in isolation to training with compound stimuli on the emergence of verbal behavior to evaluate methods that assist with correctly answering questions about compound stimuli. This study used a translational model with undergraduate students. Probes of untrained speaker and listener relations were conducted prior to training and following the emergence of the multiply controlled target intraverbal-tacts. Results show limited differences of the impact of training stimuli on acquisition and emergence. Our results also show trial arrangements that may promote emergence to untrained verbal relations. Potential clinical applications for children with autism spectrum disorder and suggestions for future research are discussed.

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Mary E. Halbur, M.S.

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INTROUDCTION

A behavior-analytic approach to language training emphasizes the function of language by examining the antecedents and consequences. Skinner's (1957) description of language, which he termed verbal behavior, defined and described several elementary verbal operants (e.g., echoic, intraverbal, tact). Each verbal operant is classified based on its functional properties and maintaining characteristics.

Several verbal operants are controlled by verbal or nonverbal stimuli. An echoic is a verbal operant evoked by a verbal discriminative stimulus, has point-to-point correspondence with the preceding verbal stimulus, and is maintained by access to a generalized conditioned reinforcer (e.g., praise, high five, access to a preferred item; Skinner, 1957). For example, a child imitates a phrase said by a parent. An intraverbal is a verbal operant evoked by a verbal discriminative stimulus and does not have point-to-point correspondence with that verbal stimulus (Skinner, 1957). The consequence for intraverbal behavior is also a generalized conditioned reinforcer. For example, the verbal stimulus "what's your name" may evoke the response "Mary," which produces the consequence "very nice to meet you, Mary." Finally, a tact is a verbal operant that is occasioned by a nonverbal stimulus (e.g., a picture, object, private event) and is followed by a generalized conditioned reinforcer. For example, an instructor holds up a picture of an apple, the learner says "apple," and the instructor provides praise. The present investigation will primarily discuss the tact and intraverbal relations.

Tact training often occurs early in comprehensive behavioral intervention for children with autism spectrum disorder (ASD; Leaf & McEachin, 1999). Sundberg and

Partington (1998) suggested that tact training helps establish more advanced language, as there are many nonverbal stimuli in an individual's environments that should be acquired such as family members, household items, toys, and other day-to-day items. Due to the substantial number of tacts that an individual should acquire, a considerable portion of behavioral intervention focuses on tact training procedures for children with ASD.

Tact training may begin with teaching simple tacts such as saying the names of pictures shown during trials (e.g., apple, pants). Over time, tact training becomes more advanced and often includes training in which tacts are under multiple sources of control (e.g., Michael et al., 2011). For example, a therapist may teach intraverbal-tacts in which the child's response is partially under the control of a nonverbal stimulus (e.g., a picture of a dog's tail) and partially under the control of a verbal stimulus (e.g., the therapist's question, "What is the dog wagging?"). Training continues to advance as the child learns to respond differentially to multiple components of the picture based on several questions about the picture. For example, the therapist may ask the child to respond differentially to a picture of a teacher holding an apple in a classroom by presenting different questions (e.g., "who," "what," and "where"). Depending on the question asked, the child would need to look at the picture, isolate the relevant component, and then provide the answer to the therapist.

The example of the teacher in the classroom with an apple described above requires a conditional discrimination. A conditional discrimination includes a conditional stimulus that modifies the function of other antecedent stimuli (Saunders & Spradlin, 1989, 1990). Responding to "who," "what," and "where" when shown a picture of a teacher in a classroom with an apple requires a conditional discrimination because the

question (i.e., either who, what, or where) alters the function of one of the components of the picture. The component of the picture (e.g., the teacher) that is relevant to the question (e.g., “who”) becomes the discriminative stimulus (S^D), and the other components become s-deltas. However, when the question changes (e.g., “where”), a different component becomes a S^D (e.g., the classroom) and the other components become s-deltas (i.e., reinforcement is not likely for behavior occurring in its presence). Children with ASD commonly have delayed acquisition of nonverbal and verbal conditional discriminations (Kodak, et al., 2015; Sundberg & Sundberg, 2011). Thus, comprehensive behavioral intervention for children with ASD frequently includes extensive exposure to conditional discrimination training (Green, 2001; Grow & LeBlanc, 2013).

Conditional discriminations with nonverbal stimuli are taught to children with ASD using various methods, although some methods may be more efficacious and efficient than others. For example, Grow et al. (2011) compared the efficacy and efficiency of training auditory-visual conditional discriminations (i.e., pointing at pictures given the name) with two procedures. Their first procedure was a simple-conditional method (Lovaas, 2003) in which a massed-trial approach was used to teach simple discriminations. For example, early steps of training involved teaching the participants to repeatedly touch one stimulus (e.g., the letter “X”). Thereafter, they taught the participants to repeatedly touch a second stimulus (e.g., the letter “B”). After training individual stimuli, training eventually progressed to teaching conditional discriminations (touching the letter X, B, or O, given the sample stimulus “X,” “B,” or “O” in each trial). Their second procedure was a conditional-only method, in which all stimuli were

simultaneously targeted for instruction from the beginning of training. That is, they taught participants to touch the letters X, B, or O given the samples, “X,” “B,” or “O” across trials from the onset of training.

The simple-conditional and conditional-only training procedures were compared because previous researchers (e.g., Green, 2001) had suggested that within the conditional-only method, differential responding is required from the onset and, therefore, may prevent the emergence of error patterns during training. Results of Grow et al. (2011) indicated that the conditional-only method was more efficient than the simple-conditional method and was efficacious for a higher percentage of participants than the simple-conditional method. Furthermore, fewer error patterns were observed during the conditional-only method.

Conditional discrimination training with nonverbal stimuli (e.g., pictures placed in an array, as in Grow et al., 2011) often occurs prior to teaching more advanced conditional discriminations such as responding to “who,” “what,” and “where” questions with names of the relevant components of a picture. In typical development, these discriminations often include a sequence of acquisition that first consists of learning component parts alone and then learning more advanced conditional discriminations (Sundberg, 2008). For example, children may first learn to label different animals that are alone on a page in a children’s book (i.e., a simple discrimination; e.g., an alligator on one page for A, a butterfly on one page for B). Then, children may learn to point to pictures of different animals together on a page in a book about the zoo while reading with their parents (i.e., nonverbal conditional discriminations). Finally, children learn to correctly answer questions about zoo animals when pictures are and are not present

(Bijou, 1976; Greer & Keohane, 2005; Sundberg & Sundberg, 2011). For example, they may answer questions such as “what is the animal eating,” “where is the zebra,” and “who is next to the zebra” while looking at a detailed page of zoo animals (i.e., intraverbal-tacts). Thereafter, they can correctly engage in intraverbal behavior about those same zoo animals in their absence (e.g., talking about zoo animals with parents while driving in the car, answering questions about where specific types of animals live).

Answering questions about zoo animals requires responses under multiple sources of stimulus control (i.e., intraverbal control from the question, and nonverbal control from an aspect of the animal pictures in the book). The sources of stimulus control occurring in these arrangements could help (DeSouza et al., 2018; Michael et al., 2011) or hinder acquisition of verbal operants. For example, training methods in DeSouza et al. resulted in acquisition of responses under multiple sources of control. In comparison, faulty stimulus control may occur during training when the visual stimuli alone control the learner’s responding instead of the auditory stimulus (i.e., question) and corresponding visual stimulus together (Green, 2001; Grow et al., 2011).

The stimulus arrangements used to teach labeling and question answering under multiple sources of control may influence whether these skills are acquired, or faulty stimulus control develops, similar to the results observed with stimulus arrangements for nonverbal conditional discrimination training (Grow et al., 2011). Using simple stimuli (i.e., one animal picture on a page) may result in quick acquisition of target(s). However, discriminated responding is not required from the onset in a simple stimulus arrangement. Therefore, when training becomes more complex, and the learner needs to attend to different pictures on a page to correctly answer a question, training with simple stimuli

may not adequately prepare the learner to be successful with learning these complex relations (Green, 2001). Alternatively, it is possible that teaching with compound stimuli (i.e., a picture that contains multiple components that will require discriminated responding) may require lengthier initial acquisition. However, it could assist with the development of future skills, such as answering questions that require discriminated responding to components of the compound stimulus. As such, it is valuable for researchers to consider the arrangement of stimuli used during training of these skills to identify efficacious procedures.

In addition, identifying stimulus arrangements that can also produce the emergence of other, untrained relations would enhance the efficiency of instruction (e.g., Axe, 2008; Devine et al., 2016; Grannan & Rehfeldt, 2012; Matter et al., 2019; May et al., 2013; Sundberg & Sundberg, 2011; Wu et al., 2019). For example, Devine et al. (2008) investigated the emergence of intraverbals following tact training with compound stimuli (i.e., pictures that contained multiple components). Post-tests probes were conducted to evaluate emergence and investigate potential variables responsible for acquisition. Following training, all participants showed some emergence of intraverbal relations under one or multiple sources of stimulus control. Due to limitations of the study design and the paucity of research on this topic, additional research on procedural arrangements that will lead to efficient acquisition of verbal operants is warranted.

One way to continue study on efficacious and efficient training procedures that emphasize emergence is to investigate procedures and trial arrangements for verbal conditional discriminations, such as teaching multiply controlled tacts (i.e., intraverbal-tacts) with conditional discrimination training procedures like those of Grow et al.

(2011). The purpose of the present experiment was to compare procedures to train and obtain emergence of intraverbal-tacts within a translational model. The present experiment is considered translational because of the inclusion of arbitrary stimuli and a nonclinical population. Arbitrary stimuli permitted an additional level of control because participants would be unlikely to have previous exposure to these stimuli nor could they look up the relations between sessions (Lowe et al., 2002). In addition, the inclusion of a nonclinical population (i.e., college students) permitted an evaluation of clinically relevant questions without yet exposing children with ASD to procedures that could limit or delay their acquisition of important skills in an area with limited previous research.

The present investigation examined acquisition of verbal operants taught with simple versus compound stimuli on acquisition and emergence of multiply controlled-tacts (intraverbal-tacts). In addition, other relations were probed prior to and following emergence of multiply controlled-tacts.

METHOD

Participants

Eight undergraduate students from a local university were recruited to participate in the present investigation. Seven of the participants were female and one was male. All participants were between 18 and 21 years old. See the first three columns of Table 1 for participant demographics (i.e., age, sex). One participant withdrew from the study after her third appointment; therefore, her data are included, however, she did not meet the mastery criterion in either condition. The Psychology participant pool was used to recruit

participants via flyers posted on the university campus. Students signed up for available research times via an online link from the study posting. A gift card was provided to each participant after the completion of the study. Depending on the participant's class and eligibility, s/he received credit for an enrolled course(s), as determined by her/his instructor(s). The academic credit was provided on vouchers following each participation session.

TABLE 1

Participant Demographics, Stimulus Assignment, and Trained Component Skills

Participant #	Age	Sex	Stimuli Assigned		Component Skills Trained
			Simple	Compound	
1	18	F	Set 1	Set 2	Tact Exemplar
2	18	F	Set 2	Set 1	Tact Exemplar
3	18	F	Set 1	Set 2	Tact Exemplar
4	19	F	Set 2	Set 1	Tact Exemplar
5	18	F	Set 2	Set 1	Tact Exemplar
6	19	M	Set 1	Set 2	Tact Exemplar
7	21	F	Set 1	Set 2	Tact Exemplar
8	21	F	Set 2	Set 1	Tact Exemplar

Note. F = female; M = male; Bold indicates the set mastered first for that participant.

Setting

Experimental sessions were conducted in a quiet room with minimal distractions on the university campus. Each room contained a table, chairs, data sheets, timers, and program materials (i.e., laminated stimuli). A partition partially separated the experimenter from the participant to assist with organization of stimulus sets and to block the view of stimuli prior to each trial.

Stimuli and Materials

Stimuli included laminated cards with pictures of arbitrary shapes, symbols, colors, and variations of orientation, size, and placement of the symbols. Categories were defined as classes/groups of stimuli with topographically similar features (e.g., colors, shapes). Four types of stimulus-card arrangements were included in the experiment and assigned to one of two conditions. The four types of stimulus cards were set 1 of simple stimuli, set 2 of simple stimuli, set 1 of compound stimuli, and set 2 of compound stimuli.

Simple stimuli consisted of cards that contained one component (e.g., one color, shape, or symbol). Refer to Appendices A and B for representations of the simple stimuli and their assigned arbitrary names for the experiment. Each set contained 9 exemplars, 3 of each component. Compound stimuli consisted of cards that contained all components presented together (e.g., one color, one shape, and one symbol per card). Refer to Appendices C and D for examples of nine of the 27 stimulus combinations for each set, respectively. There were 27 compound stimulus cards for each set to measure responding to all possible combinations of stimuli in the set. Nine of the compound stimulus cards in each set were assigned to a training set, nine were assigned to a set for the pretests and

posttests, and nine were assigned to a set for multiply controlled tact probes. Each set contained three presentations of each exemplar in various arrays, such that no duplicates occurred across the 27 combinations.

Each participant was exposed to one set of simple stimuli and one set of compound stimuli. The stimulus sets were arbitrarily assigned to each condition and alternated across participants. Four of the completed participants were exposed to stimulus sets 1 and 2 assigned to simple and compound training conditions, respectively. The other three participations were exposed to stimulus sets 2 and 1 assigned to simple and compound training conditions, respectively. The participant that dropped out was also assigned to the second arrangement. The fourth and fifth columns of Table 1 display stimuli assigned to each condition (i.e., simple or compound) across participants.

Arbitrary stimuli and names were selected to prevent participants from having prior exposure to any of the relations that were to be taught and tested in the experiment, and to prevent participants from being able to search and obtain additional exposure to the relations between appointments. Additionally, a video camera was positioned in the room to record sessions for reliability and integrity data collection.

Experimental Design

An adapted alternating treatments design (Sindelar et al., 1985) was used for each participant to examine the effects of training type on trained relations and the emergence of multiply controlled tacts. Sessions of each condition were alternated, and no more than two sessions of the same condition were conducted sequentially, unless one condition had met the mastery criterion. The mastery criterion for training was one session with 100% correct independent responses. Three probe trials were included in training sessions to

measure the emergence of intraverbal-tacts. The mastery criterion for interspersed probes was three consecutive sessions with 89% correct independent responses. Sessions of training in a condition continued following attainment of the mastery criterion until probes reached mastery level responding or were stable or on a decreasing trend for three consecutive sessions. In addition, training in each condition continued until training of all three components was completed or participants met the maximum duration of research sessions (i.e., 10 appointments). No participants reached the maximum duration of training. See Appendix E for a sequence of procedures diagram.

Response Measurement

Terminal Probes

The primary dependent variable for both conditions was the percentage of correct independent responses during interspersed probes of multiply controlled tacts, defined as correctly saying the name of one component of the compound stimulus that corresponds to the antecedent verbal stimulus. For example, the experimenter held up one stimulus card with a component from all three categories on it and stated one of the categorical names (for a list of categorical names, see the first columns of Appendix A and B). A correct response was defined as the participant tacting the correct component of that category (e.g., experimenter says “Ved,” participant says “Dop” for all targets in the first row of the diagram in Appendix A). The percentage of correct independent responses was calculated by dividing the number of correct independent responses by the total number of components per session, multiplied by 100. Errors during terminal probes were defined as any vocal verbal behavior (except swearing or vocalizations associated with thinking

out loud such as “um”) during the 5-s response interval other than the target response. No responses during terminal probes were defined as no vocal verbal behavior during the 5-s response interval.

Component Skill Training

During tact exemplar training, a correct independent response was defined as saying the name of the item on the simple stimulus card (i.e., a stimulus that contained one component; either the color, shape, symbol, placement, orientation, or size) within 5 s of the antecedent verbal stimulus. Errors and no responses followed the same definitions as the terminal probes (listed above). In the compound-stimulus condition, a correct independent response was defined as the participant saying the name of the item that the experimenter pointed to in the compound stimulus within 5 s of the experimenter touching the relevant stimulus component and providing the antecedent verbal stimulus.

None of the participants required training of the phases that followed tact training; these training phases would have involved categorical auditory-visual conditional discrimination and intraverbal training. However, operational definitions were identified apriori for categorical auditory-visual conditional discrimination and intraverbal training (See Appendix F).

Interobserver Agreement and Treatment Integrity

Two trained, independent observers collected data on participant behavior during sessions and from video recordings. Interobserver agreement (IOA) was calculated using the trial-by-trial method. Scores for trials were compared, and an agreement was defined as the two observers scoring the exact same behavior during each trial. For example, a

trial was scored as an agreement if both observers recorded a correct independent response during the trial. A disagreement was defined as two observers recording a different behavior during the trial (e.g., one observer recorded a correct independent response, and the other observer recorded a ‘no response’). All components of the trial were required to be recorded identically for the trial to be scored as an agreement. For example, for terminal probes, all three components (each category) had to be in agreement for that trial to be scored as correct. The number of trials with an agreement was divided by the total number of trials and multiplied by 100. Reliability data were collected for a minimum of 48% of sessions for each participant across conditions and for 96% of the pretest and posttest trials for each participant. See Table 2 for participant-by-participant IOA.

TABLE 2

Interobserver Agreement Across Participants

P #	Conditions			Pretests/Posttests		
	% w/IOA	IOA	Range	% w/IOA	IOA	Range
1	67	96	67-100	100	100	-
2	100	98	92-100	100	100	-
3	100	96	83-100	100	95	88-100
4	48	97	83-100	96	98	95-100
5	100	98	83-100	100	99	96-100
6	96	99	92-100	100	98	96-100
7	100	97	92-100	100	98	96-100
8	67	97	89-100	100*	100*	-

Note. P = participant, IOA = interobserver agreement, * = pretest only

Treatment integrity data were also collected for a minimum for 48% of sessions for each participant. An observer collected data on whether the experimenter implemented all aspects of the trial according to the procedures in the experimental protocol. Observers evaluated whether the experimenter secured attending (i.e., waited for the participant to look at the picture), presented the correct stimulus card, presented the correct discriminative stimulus and in the correct order, presented correct prompts and at the appropriate times, provided reinforcement when relevant, and did not provide any additional feedback or prompts. The experimenter was required to implement all components of the trial correctly to receive a score of 1; if one or more components were not conducted correctly, the trial was scored as a 0. Treatment integrity was calculated by dividing the number of trials scored as a 1 by the total number of trials per session, multiplied by 100. See Table 3 for participant by participant treatment integrity scores.

TABLE 3

Treatment Integrity Data Across Participants

P #	Conditions			Pretests/Posttests		
	% w/TI	TI	Range	% w/TI	TI	Range
1	67	96	75-100	100	99	96-100
2	100	100	-	100	100	-
3	100	100	-	99	100	-
4	48	100	-	96	100	-
5	100	99	83-100	100	100	-
6	96	100	-	100	100	-
7	100	99	92-100	100	100	-
8	67	100	-	100*	100*	-

Note. P = participant, TI = treatment integrity, * = pretest only

Probes of Stimulus Relations

Prior to training and following the emergence of multiply controlled tacts, the experimenter probed several stimulus relations. See Appendix G for a description of each of the probed relations. Probe sessions included a mixture of types of relations (i.e., speaker and listener responses of exemplars and categories, intraverbals). Each participant took two pretests and two posttests (i.e., one with each group of stimuli). During all posttest sessions, no feedback (i.e., prompts or reinforcement) was provided for correct or incorrect responses to the probed relations. Participants were told that the experimenter was not able to provide any feedback during these sessions, but to still try their best to respond if they thought they knew the answer.

Terminal Probes of Multiply Controlled Tacts

Multiply controlled tacts were probed throughout each training session. Three probe trials, with three components each, were randomly interspersed in the 9-trial training sessions, making all sessions 12 trials. Probe trials were arranged so that all nine components of each set were presented once within a session (within combinations of three exemplars of three components). The probes were arranged into groups of three, so that to meet the mastery criterion, the participants were required to respond correctly to a majority of the nine targets that were assigned to the set of multiply controlled tact probes (i.e., 3 consecutive sessions with 89% correct independent responses).

During probe trials, the experimenter presented a compound stimulus, secured the participant's attention to the stimulus, and presented each auditory sample stimulus (e.g., "Ved," "Ral," and "Pog" or "Yat," "Jud," and "Tef") in a randomized order. Thus, each

trial was comprised of an opportunity to tact the three individual components of the compound stimulus in the presence of the relevant auditory sample stimulus (e.g., the participant could tact “Dop” after the experimenter said “Ved,” the participant could tact “Mig” after the experimenter said “Ral,” and the participant could tact “Jaf” after the experimenter said “Pog”). No feedback was provided following responses (correct, errors, and no responses). Probe sessions continued until the mastery criterion was met.

Baseline and Training

Participants were exposed to baseline and training of skills programmed to occur in a specific sequence, beginning with tact exemplar training. During tact exemplar training, each session was comprised of nine trials, with each stimulus for that condition presented once per session. During each trial of the simple stimuli condition, the experimenter presented a simple stimulus (e.g., a card that contained one symbol) and secured the participant’s attention. The experiment then presented an antecedent verbal stimulus (e.g., category name; “Ral”) immediately prior to the 5-s response interval. During each trial of the compound stimuli condition, the experimenter presented a compound stimulus, pointed to the component within the stimulus to secure the participant’s attention to that component, and provided the category antecedent verbal stimulus prior to the 5-s response interval.

During baseline for both conditions, no feedback was provided following correct responses, errors, and no responses. Participants were told that the experimenters had to make sure they were not familiar with the questions, so feedback would not be provided. After one baseline session was conducted for the tact exemplars, the participant was told that sometimes the experimenter would provide assistance and praise for correct answers

and sometimes the experimenter would not, but to do their best to respond on all trials. During the tact exemplar training trials, the experimenter provided praise following correct independent responses. If the participant made an error or did not respond, the antecedent verbal stimulus (i.e., category name) and vocal model of the correct response was repeated every 5 s until the participant engaged in a correct prompted response. The experimenter also provided praise following prompted correct responses. Exemplar tact training continued until the mastery criterion of one session with 100% correct independent responses was met, and the terminal probes met mastery or were on a stable or decreasing trend for three consecutive sessions.

Additional phases of training to teach categorical auditory-visual conditional discriminations and intraverbals would have occurred if mastery level responding to terminal probes did not occur during or immediately following tact exemplar training. However, these phases of training were unnecessary as all participants had mastery level responding to terminal probes following tact exemplar training. See Appendix H for an explanation of these training procedures, if they would have been necessary during training.

RESULTS

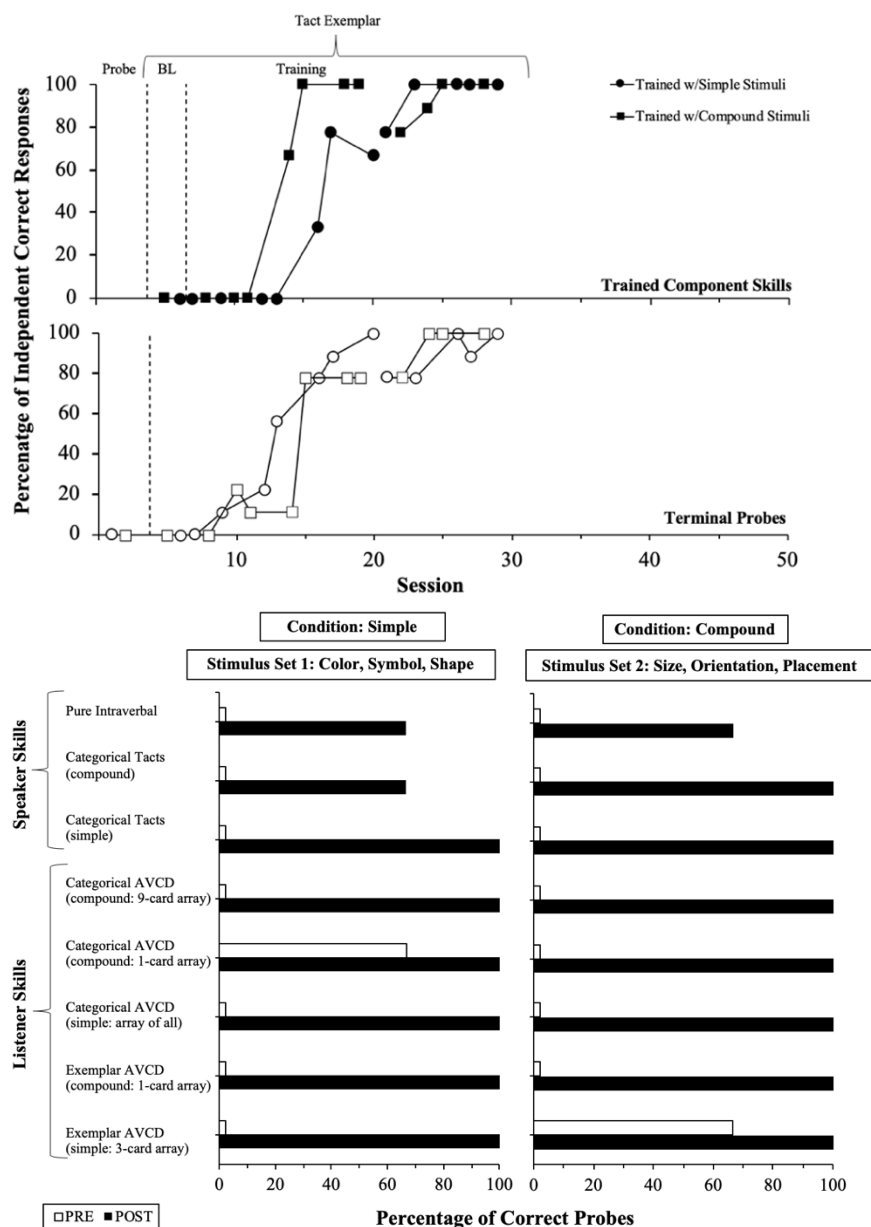
Results for each participant are shown in Figures 1-8. The top graph of each figure displays session-by-session acquisition of trained targets (top panel; closed data paths) and emergence of multiply controlled tacts (second panel, open data paths) for each condition (i.e., circles represent targets trained with simple stimuli, squares represent targets trained with compound stimuli). The seven participants that completed

the study reached the mastery criterion for terminal probes of multiply controlled tacts with tact exemplar training only (See Table 1, last column). The set that was mastered first is also bolded in columns 4 and 5 of Table 1. Individual participants pretest and posttest results are also presented in the bottom panels of Figures 1-8. The far-left bars represent the pretests and posttests with simple stimuli and the far-right bars represent pretests and posttests with compound stimuli.

Figure 1 shows participant 1's results. In the top two panels, the breaks in the data paths for each condition represent a break of 1 week or greater between appointments. Due to the holiday break during this time period, tacts were re-trained across conditions to ensure they were at mastery level. Participant 1 required 12 training sessions for the simple stimuli condition and 11 training sessions for the compound stimuli condition to reach the mastery criterion for the terminal probes. Pretest results indicated low levels of correct independent responses (bottom panel). One skill in each stimulus set had elevated levels of correct responding; however, this occurred across both sets of stimuli and did not occur across the different pretest trial arrangements (i.e., categorical auditory-visual conditional discrimination, 9-card array). Posttest results show 100% correct independent responses across listener skills in both sets of stimuli. Tact and intraverbal relations were also elevated in the posttests compared to the pretest levels.

Figure 1

Tact Exemplar Training (Top panel), Multiply Controlled Tact Emergence (Second Panel), and Pretest and Posttest Results (Bottom Graphs) for Participant 1



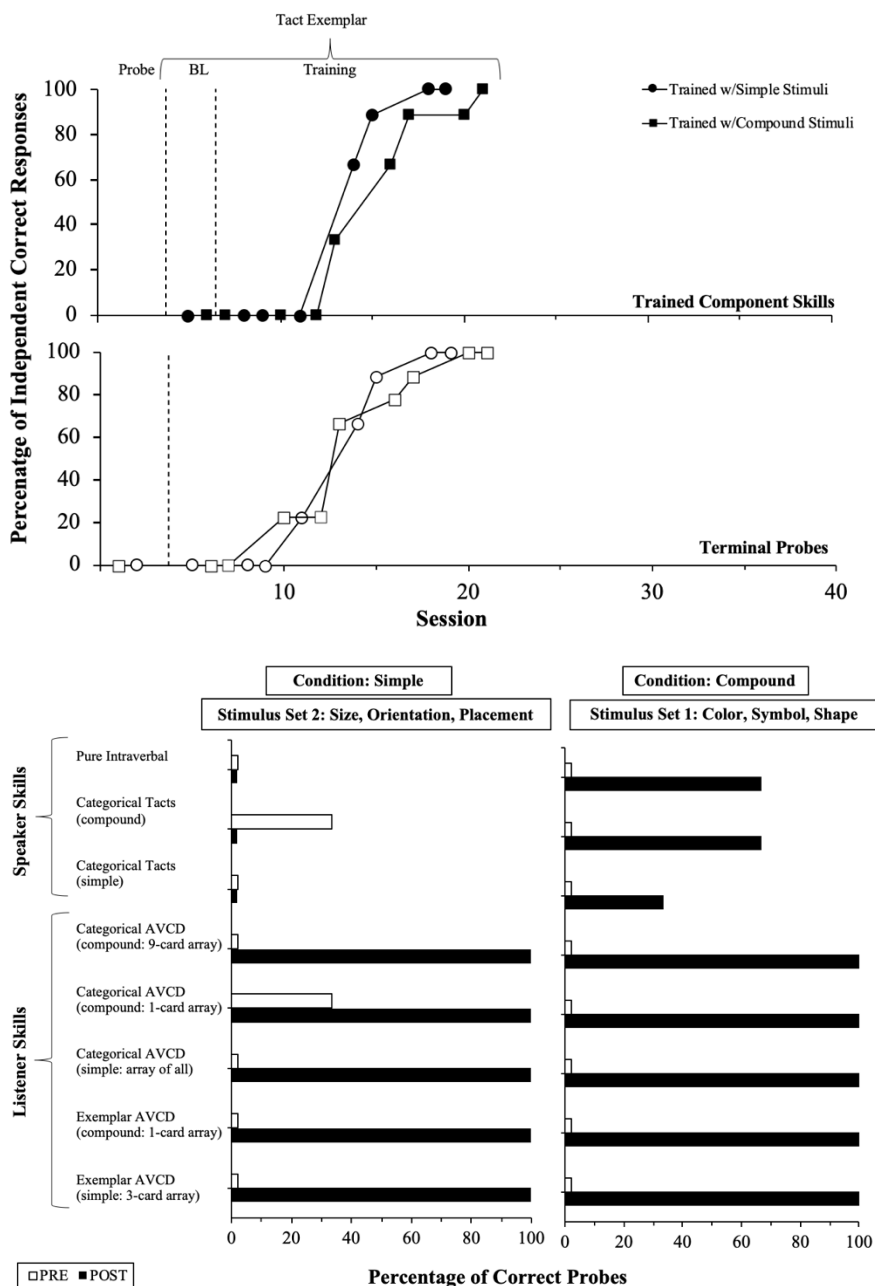
Note. AVCD = auditory-visual conditional discriminations. Listener skills required the participant to select from an array of cards or point to a component. Speaker skills required a vocal response. Break in data path in the top panel represents a 1-week break between sessions.

Figure 2 displays participant 2's results. Participant 2 required seven training sessions for the simple stimuli condition and eight training sessions for the compound stimuli condition to reach the mastery criterion for the terminal probes. Pretests data show low levels of correct independent responses. For set 1 in posttests, tact and intraverbal relations were slightly elevated compared to the pretest levels; however, participant 2 did not engage in high levels of correct category tacts or intraverbals in stimulus set 2 posttests that were associated with the simple stimuli condition.

Figure 3 displays participant 3's results. Participant 3 required eight training sessions for the simple stimuli condition and seven training sessions for the compound stimuli condition to reach the mastery criterion for the terminal probes. Similar to the other participants, pretest results show low levels of correct independent responses, except for a few listener skills in which responding was around chance level. Posttests results show 100% correct independent responses for all listener skills and low levels of correct responses to the category tact and intraverbal relations.

Figure 2

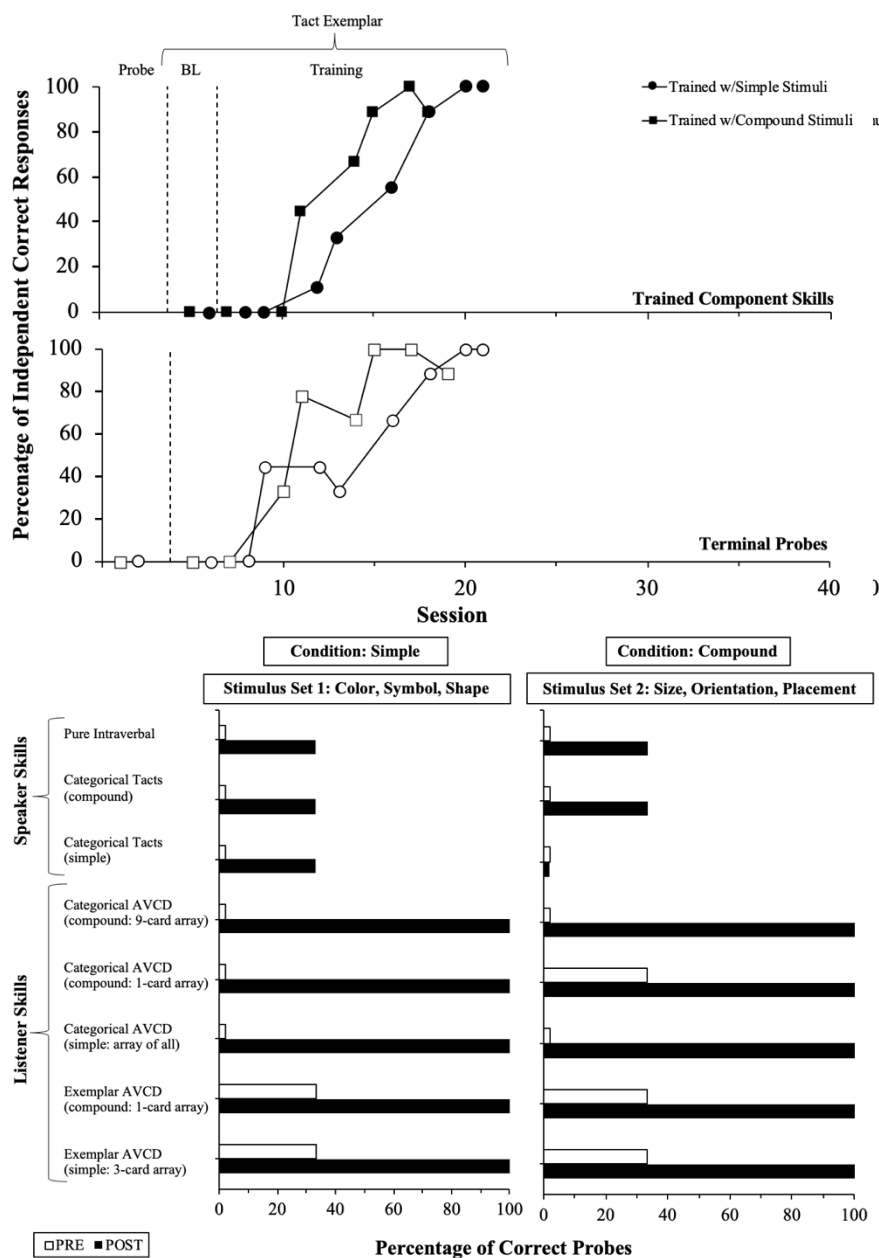
Tact Exemplar Training (Top panel), Multiply Controlled Tact Emergence (Second Panel), and Pretest and Posttest Results (Bottom Graphs) for Participant 2



Note. AVCD = auditory-visual conditional discriminations. Listener skills required the participant to select from an array of cards or point to a component. Speaker skills required a vocal response.

Figure 3

Tact Exemplar Training (Top panel), Multiply Controlled Tact Emergence (Second Panel), and Pretest and Posttest Results (Bottom Graphs) for Participant 3



Note. AVCD = auditory-visual conditional discriminations. Listener skills required the participant to select from an array of cards or point to a component. Speaker skills required a vocal response.

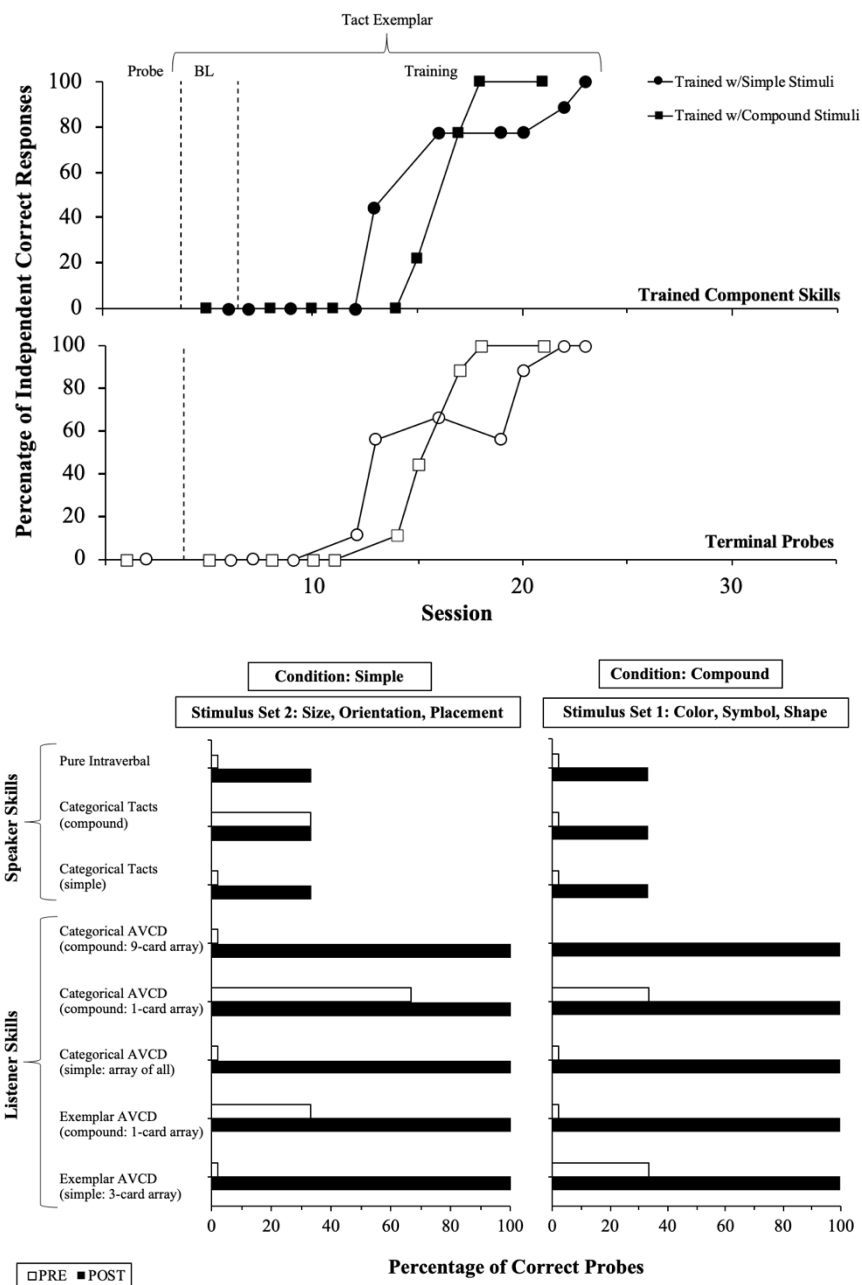
Results for participant 4 are displayed in Figure 4. Nine and eight training sessions were required to reach the mastery criterion for terminal probes in the simple and compound stimuli conditions, respectively. Pretest and posttest results followed a similar pattern as the other participants with moderately low levels of correct responses across both stimulus sets in the pretests (i.e., 0%–66%). Posttests results also show high levels for listener skills and low levels (33%) for speaker skills (i.e., category tacts) across both sets of stimuli and conditions.

Figure 5 displays participant 5's results. She required seven training sessions for the simple stimuli condition and 13 training sessions for the compound stimuli condition to reach the terminal probe mastery criterion. Posttests results show 100% correct independent responses for all listener skills and variable levels of correct responses to speaker category skills. Participant 5 scored higher in set 1 posttests (compound stimuli condition) for tact and intraverbal relations than set 2 (simple stimuli condition). However, this could potentially be attributed to the additional practice with these targets during her training sessions.

Figure 6 displays participant 6's results. She required 12 training sessions for the simple stimuli condition and eight training sessions for the compound stimuli condition to reach the terminal probe mastery criterion. Pretests scores indicated low levels of correct independent responses across trial arrangements and sets of stimuli. Posttests results show high levels of correct independent responses across listener skills and zero or low levels of correct responses to tact and intraverbal relations.

Figure 4

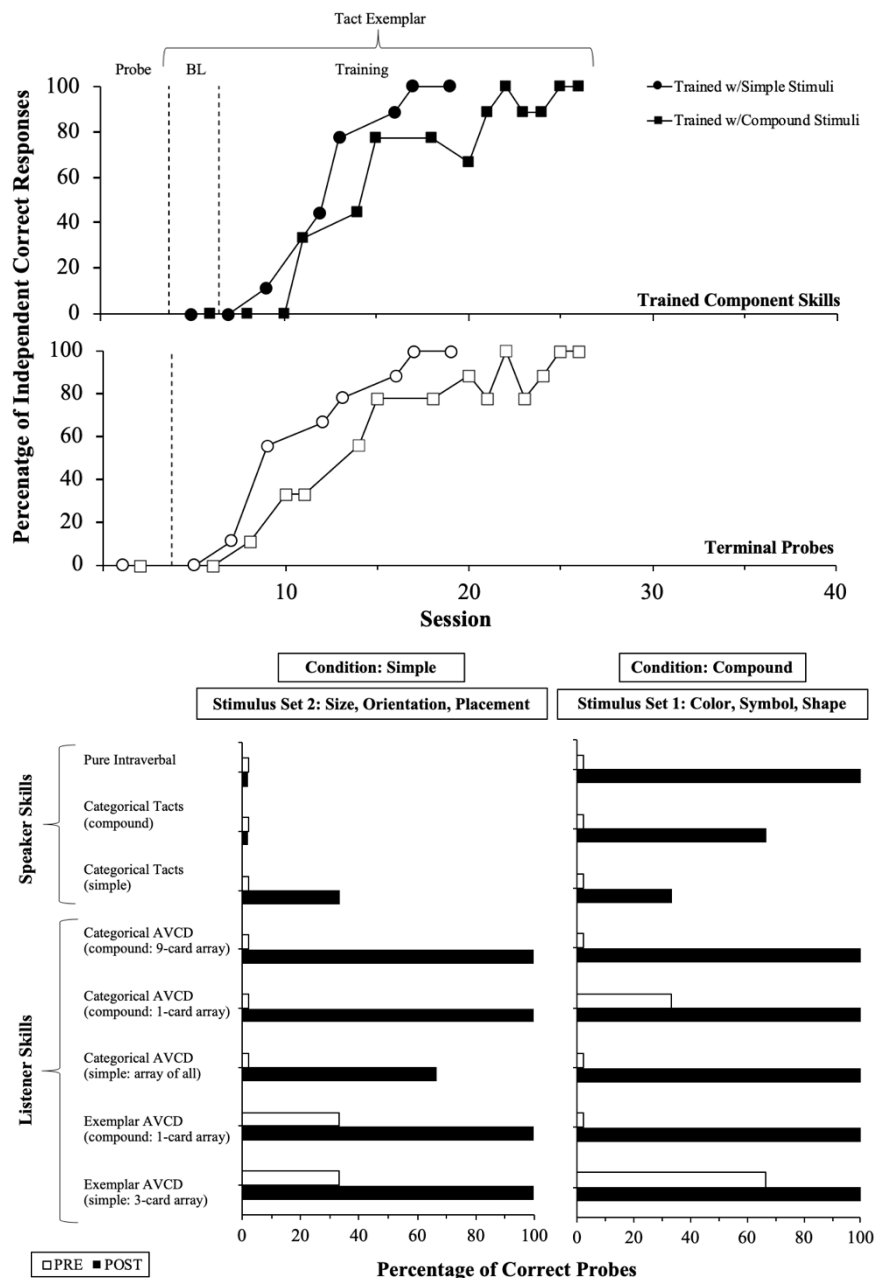
Tact Exemplar Training (Top panel), Multiply Controlled Tact Emergence (Second Panel), and Pretest and Posttest Results (Bottom Graphs) for Participant 4



Note. AVCD = auditory-visual conditional discriminations. Listener skills required the participant to select from an array of cards or point to a component. Speaker skills required a vocal response.

Figure 5

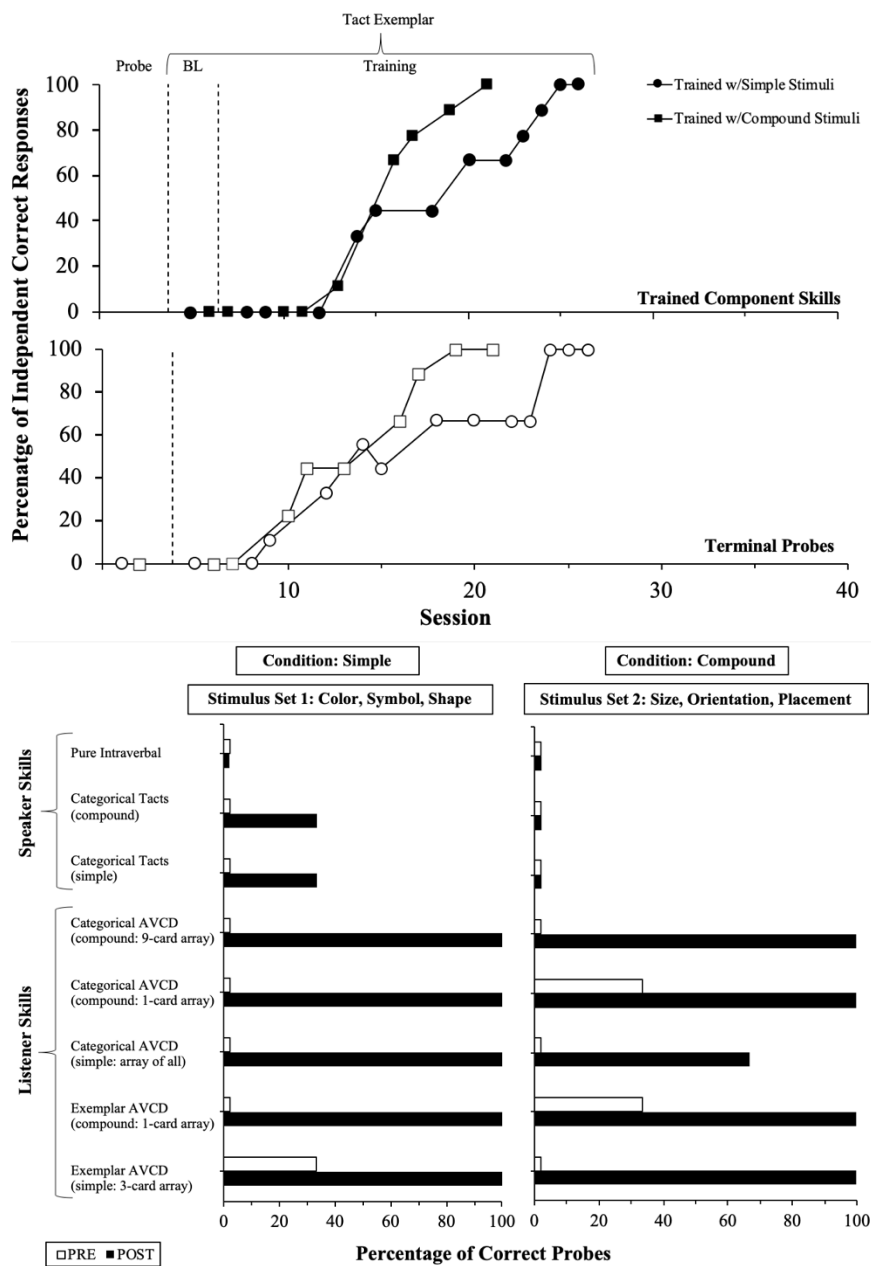
Tact Exemplar Training (Top panel), Multiply Controlled Tact Emergence (Second Panel), and Pretest and Posttest Results (Bottom Graphs) for Participant 5



Note. AVCD = auditory-visual conditional discriminations. Listener skills required the participant to select from an array of cards or point to a component. Speaker skills required a vocal response.

Figure 6

Tact Exemplar Training (Top panel), Multiply Controlled Tact Emergence (Second Panel), and Pretest and Posttest Results (Bottom Graphs) for Participant 6



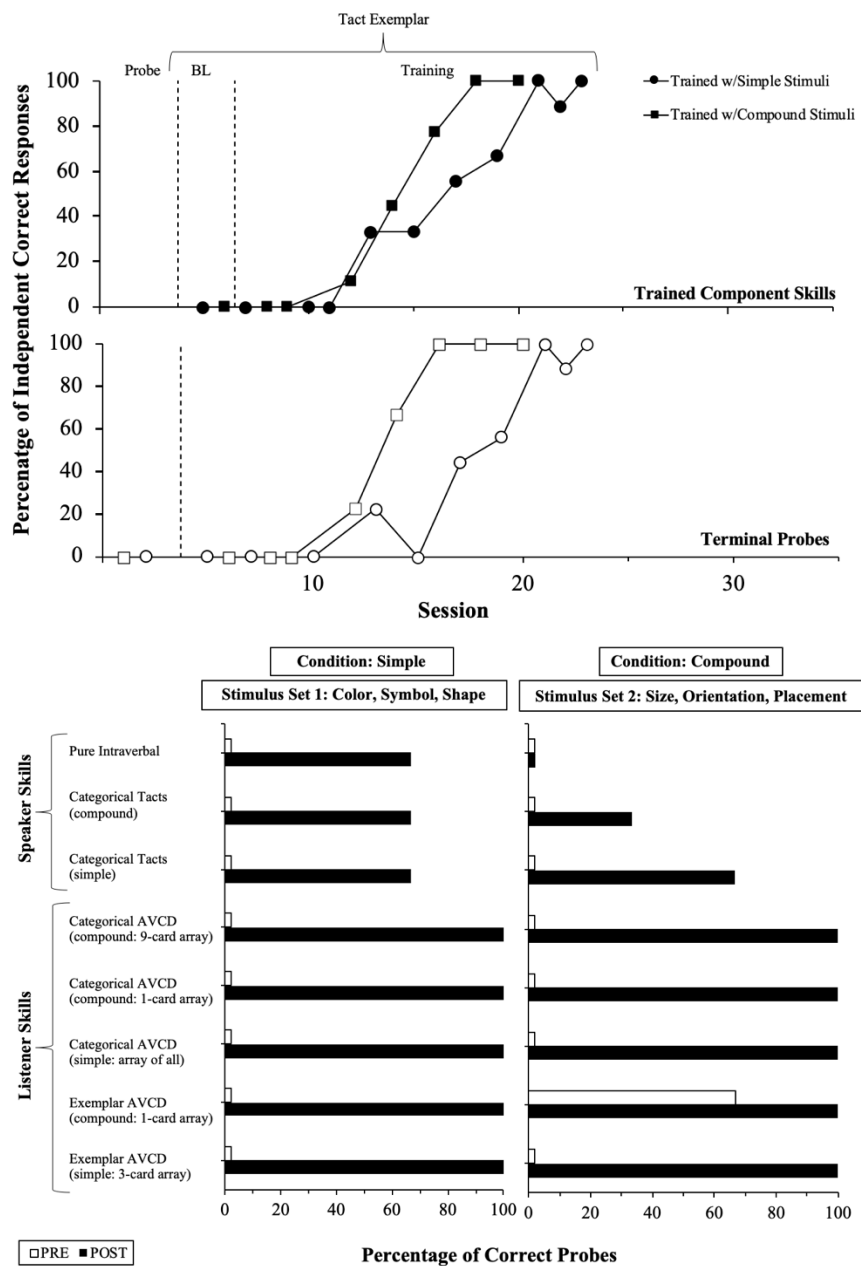
Note. AVCD = auditory-visual conditional discriminations. Listener skills required the participant to select from an array of cards or point to a component. Speaker skills required a vocal response.

Results for participant 7 are displayed in Figure 7. Ten and seven training sessions were required to reach the mastery criterion for terminal probes in the simple and compound stimuli conditions, respectively. Pretest and posttest results followed the same pattern of responding as the other participants with moderately low levels of correct responses across both sets/conditions of stimuli in the pretests (i.e., 0%–66%). Posttest results show 100% correct independent responses for listener skills. Similar to other participants, tact and intraverbal relations were at moderate to low levels (0%–67%) across conditions in the posttests.

Results for participant 8 who withdrew from the study are displayed in Figure 8. At the time of her withdrawal, both conditions had similar levels of correct independent responding in tact training and within terminal probes. Her pretest results show 0%–33% correct independent responses across all skills in each stimulus set. No posttest probes were conducted with participant 8 due to her withdrawal.

Figure 7

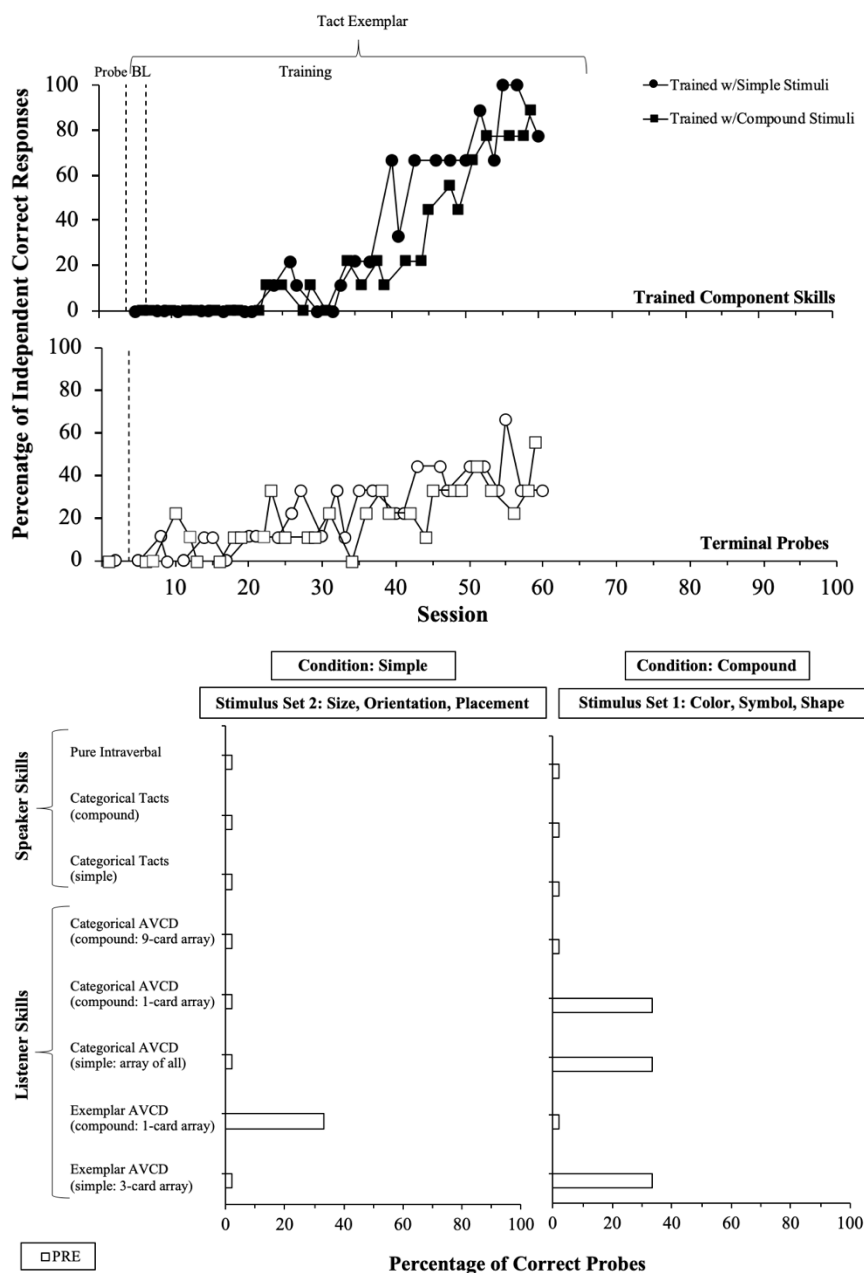
Tact Exemplar Training (Top panel), Multiply Controlled Tact Emergence (Second Panel), and Pretest and Posttest Results (Bottom Graphs) for Participant 7



Note. AVCD = auditory-visual conditional discriminations. Listener skills required the participant to select from an array of cards or point to a component. Speaker skills required a vocal response.

Figure 8

Tact Exemplar Training (Top panel), Multiply Controlled Tact Emergence (Second Panel), and Pretest and Posttest Results (Bottom Graphs) for Participant 8

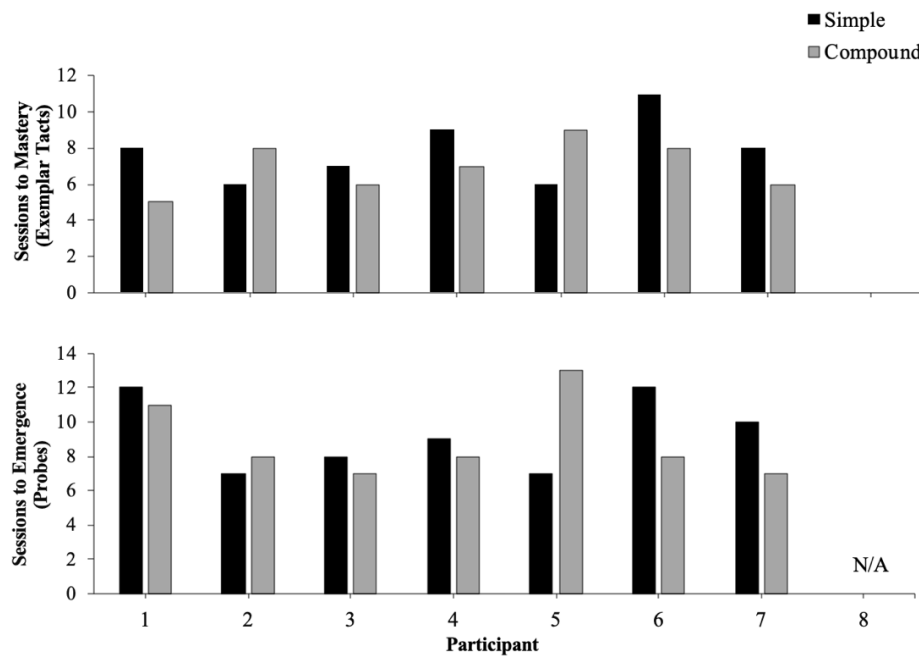


Note. AVCD = auditory-visual conditional discriminations. Listener skills required the participant to select from an array of cards or point to a component. Speaker skills required a vocal response. Data for participant 8 is shown prior to her withdrawing from the study.

Figure 9 indicates the overall number of sessions until tact exemplar training reached the mastery criterion across participants as well as the number of sessions until multiply controlled tacts emerged at the mastery criterion for each participant. The difference in the number of sessions until mastery of tact training across conditions for each participant ranged from 1 to 3. Similarly, the difference in the number of sessions until terminal probes emerged across conditions (simple or compound stimuli) for each participant ranged from 1 to 6. Visual analysis of session-by-session data, in combination with overall sessions to mastery, suggested few differences in acquisition and emergence between conditions of simple or compound training arrangements.

Figure 9

Sessions to Tact Exemplar Mastery (Top Panel) and Terminal Probe Emergence (Bottom Panel) Across Participants

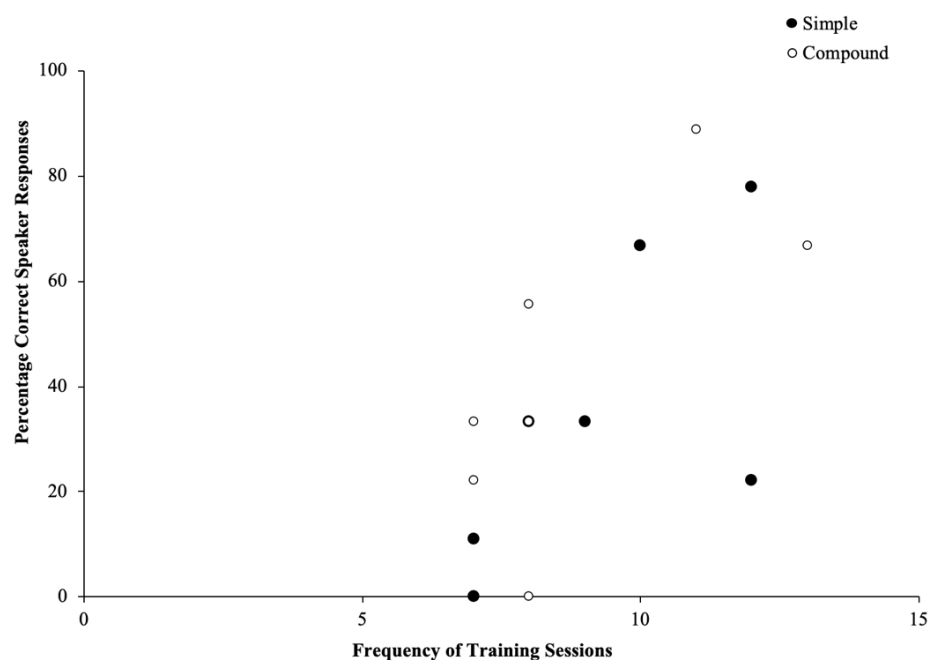


Note. N/A represents the participant that withdrew from the study.

Figure 10 displays individual participant data for the speaker relations (category tacts and intraverbals) in the posttests. Results show the amount of training sessions that each participant received (x-axis) and percentage of correct speaker responses as means across the speaker posttest probes (y-axis). Each participant is displayed by two dots (i.e., white circles indicate stimuli trained in the compound condition, and black circles indicate stimuli trained in the simple condition). Thus, if the frequency of training sessions were to impact the posttest speaker responses, we would expect to see a linear pattern. For example, the percentage of correct speaker responses would increase as the number of training sessions increase. The results suggest a potential linear relation between the number of training sessions and the percentage of correct speaker responses.

Figure 10

Jittered Participant Data for Speaker Responses in the Posttests



Note. Each data point represents 1 (of 2) posttests for each participant.

DISCUSSION

Results of all participants in the present investigation indicate both training conditions (simple and compound) produced acquisition of exemplar tacts and facilitated the emergence of intraverbal-tacts during terminal probes. However, results show limited differences between training methods on the acquisition and emergence of targets. Across conditions, listener skills emerged following tact exemplar training. However, limited emergence of speaker skills was observed in posttests. Taken together, the results of the present investigation contribute to research on multiple control within simple and conditional discrimination training while also extending research on the efficacy and efficiency of training with simple and compound stimuli.

Some researchers have suggested introducing increasingly difficult discriminations over time by starting training with simple discriminations prior to teaching conditional discriminations (e.g., Dube et al. 1993; Lovaas, 2003), whereas other researchers have suggested methods for conditional discrimination training that focus on combined arrangements from the onset to promote appropriate stimulus control and limit error patterns that stall learner progress (Green 2001; Grow et al., 2011; Grow et al., 2014). The results of the present investigation are inconsistent with those of Grow et al. (2011), in that we observed limited differences in teaching simple versus conditional verbal discriminations (i.e., relations trained with simple versus compound stimuli). Said another way, when differential discriminated responding was required from the onset of training, as in our compound stimuli condition, it did not seem to prevent the emergence of error patterns during training or lead to more efficient outcomes. Ultimately, both conditions (simple and compound training stimuli) led to the emergence

of multiply controlled tacts in a similar number of tact exemplar training sessions, and we did not observe any procedural aspects likely to promote faculty stimulus control. In addition, both stimulus arrangements led to similar levels of correct responding in the posttests of other stimulus relations.

The results of the present investigation may differ from previous studies on simple and conditional discrimination training based on specific methods used in the present study. For example, the current study alternated the auditory stimulus on every trial (e.g., “Ved,” “Ral,” and “Pog” occurred three times each across the 9 tact training trials each session) across conditions. This alternation of auditory stimuli was programmed from the onset of training. In comparison, the simple-conditional method in Grow et al. (2011) began with the presentation of the same auditory stimulus on every trial (e.g., “X”). The learner selected a letter (e.g., X) from an array in which only one letter was present (the other two cards in the array were blank). This initial training in Grow et al. may teach the learner that it is unnecessary to attend to the auditory stimulus to respond correctly to the visual stimuli. In their later steps of training, the auditory stimulus varied across trials and additional visual stimuli were included in the array. The results of Grow et al. show that participants began making errors once training required the participants to attend to the auditory stimulus in order to respond differentially to visual stimuli in the array. The inclusion of varying auditory stimuli in the present investigation may help prevent the error pattern of failing to attend to the auditory stimulus during simple discrimination training, although additional research that directly evaluates the effects of consistent versus varying auditory stimuli during training is necessary to answer this question.

The present investigation also arranged varying visual stimuli from the onset of instruction. In the simple stimulus condition, each visual stimulus was presented one time per session. However, those stimuli only included one component (e.g., one shape, color, or symbol). In the compound stimulus condition, the visual stimulus included all three components (e.g., the shape, color, and symbol), and the arrangement of these components varied across trials (e.g., shape 1 was shown with color 1 and symbol 1 on one trial, and shape 1 was shown with colors 2 and 3 and symbols 2 and 3 on other trials). Additionally, the specific component targeted on the nine compound stimulus cards varied across training sessions. For example, when the stimulus with components Dop, Mig, and Jaf was presented, the experimenter differentially touched the color, shape, or symbol across sessions. In comparison, Grow et al. (2011) included the same visual stimulus of one letter on all trials in the initial steps of training. Varying visual stimuli across trials may increase the likelihood that the participant attends to the stimuli (e.g., Etzel & LeBlanc, 1979). Additional evaluations of the effects of varying visual stimuli during simple discrimination training will assist in the identification of ideal conditional discrimination training arrangements for learners.

The outcomes of the present study suggest that several variables may have contributed to the obtained results. First, the efficacy of tact exemplar training and the resulting emergence of multiply control tacts could be due to the combinations of trial arrangements. Both conditions included alternation of the auditory and visual stimuli across trials. This variation in training may promote attending to both stimuli that should eventually come to control the response. In contrast, Grow et al. (2011) included the same letter name (e.g., E) and visual stimuli on every trial in early training in the simple-

conditional method but varied these stimuli throughout training in the conditional-only method. It is possible that we would have observed differences in the simple and conditional stimuli conditions in the present investigation if the simple stimuli condition did not include varied auditory and visual stimuli from the onset of training. For example, the experimenter could have presented a single stimulus (e.g., one shape) with the same antecedent verbal stimulus (e.g., “Pog”) on every trial (referred to as massed trial training in early intervention manuals; Lovaas, 2003) until responding met mastery before introducing training with a second stimulus. However, previous research shows massed trial training is not as efficient as varied-trial arrangements (e.g., Cariveau et al., 2016; Grow et al., 2011). Thus, the varied-trial arrangement in the current study may have reduced any potential differences in the efficacy and efficiency of training with simple versus compound stimuli.

In the present study, the participants could have simply attended to the visual stimulus to respond correctly during tact exemplar training. However, the emergence of multiply controlled tacts in the terminal probes suggested that the participants also attended to the auditory stimulus (i.e., the antecedent verbal stimulus). The terminal probes required responding under multiple control because the participant had to attend to the auditory stimulus as well as the visual stimulus to correctly respond. If only one source of control occurred (e.g., the participant attended to the visual stimulus only), their correct responding would have been at chance levels. Thus, participants in the current study attended to both auditory and visual stimuli during tact exemplar training, which is inconsistent with some of the participants in previous research who only attended to one component of training (e.g., the visual stimuli; Lovaas et al., 1979; Grow et al., 2011). It

is likely that the training format across both conditions fostered attending to both the visual and auditory components of instruction, or at minimum, attention to the fact that there were different relations present from the onset.

Another variable that may have impacted acquisition and emergence is the inclusion of an antecedent verbal stimulus (i.e., category name; “Ved”) within training. Some curriculum manuals for children with ASD have suggested pairing the presentation of visual stimuli with supplemental questions (e.g., “What is it?”; Leaf & McEachin, 1999; Lovaas, 2003; Marchese et al., 2012), or initially pairing them with supplemental questions and then fading them over time (Sundberg & Partington, 1998). The inclusion of supplemental questions (i.e., antecedent verbal stimuli) is commonplace in early intervention programs (Sundberg & Partington, 1998) and was present across both conditions in our tact exemplar instruction. This component of intervention may facilitate the emergence of multiply controlled responses that occurred during probes.

Although the participants were not required to respond differentially to these antecedent verbal stimuli during training, participants frequently echoed them during initial trials (e.g., the experimenter said “Ral” and the participant echoed “Ral” rather than saying the name of the visual stimulus on the card). Echoics of the antecedent verbal stimuli reduced over time as the participants began engaging in correct tacts, but the initial attending to the antecedent verbal stimuli in the form of echoic responses may have facilitated the emergence of intraverbal-tacts during subsequent probes. Therefore, future researchers could investigate the inclusion of antecedents during tact training. For example, researchers could arrange tact training with and without antecedent verbal

stimuli (i.e., the experimenter holds up the card and says nothing during the response interval) and compare the outcomes to those in the present investigation.

It is possible that the auditory stimuli included in the investigation became conditioned, automatic positive reinforcers. Anecdotally, participants sometimes reported that they thought certain auditory stimuli were “fun.” Thus, echoing the auditory stimuli either overtly or covertly and achieving parity may have produced automatic reinforcers which increased the occurrence of these behaviors during training (Vaughan & Michael, 1982; Wu et al., 2019). The automatic reinforcement hypothetically present within these training procedures may have increased echoic and self-echoic behavior of the antecedent verbal stimulus or the antecedent verbal stimulus with the tact exemplar for some participants. These echoics may have assisted with acquisition of the tact exemplar targets and the terminal probes (if participants were covertly echoing the antecedent portion of the trial). Said another way, the amount of exposure to repeating (echoing) the category tact while learning the tact exemplar names may have impacted acquisition and emergence.

The posttest probes of speaker behavior (e.g., saying the category name) suggested that exposure to a greater number of training sessions increased scores for some participants. Additional training sessions afforded the participants more opportunities to engage in echoic and self-echoics of the antecedent verbal stimulus that could lead to higher scores on probes of speaker behavior, although the present study did not include measures of echoic behavior nor methods for examining the effects of echoic behavior on responding. Future research could include measures of echoic behavior

across conditions and examine the effects of exposure to antecedent verbal stimuli on correct responding during speaker behavior posttests.

The differences in outcomes in the present investigation compared to Grow et al. (2011) could also relate to the participants. Grow et al. compared simple and conditional discrimination training with young learners with ASD who had a weak repertoire of auditory-visual conditional discriminations. In comparison, the present investigation included undergraduate students who presumably have well-developed conditional discrimination repertoires (e.g., they can read, complete college-level math problems, engage in conversations). Nevertheless, the types of discriminations taught in the present investigation are more advanced than those targeted by Grow et al. Children with ASD (and typically developing children) who will be exposed to the instructional arrangements in the present investigation should already have learned many simple and conditional discriminations (e.g., tacts, correct responses to picture arrays teaching early-to-advanced listener discriminations) as well as many simple and conditional verbal discriminations (e.g., fill-in-the-blank responses, response to “wh” questions). Thus, it is possible that the observed error patterns and faulty stimulus control resulting from simple discrimination training in Grow et al. would be unlikely to occur when a simple discrimination training method is used to teach and probe emergence of intraverbal-tacts with undergraduate students as well as more advanced learners with ASD.

Nevertheless, the undergraduate students in the present investigation engaged in certain patterns of responding that are consistent with those observed during comprehensive behavioral intervention for children with ASD. For example, following vocal prompts of the tact exemplars, some participants initially repeated irrelevant parts

of the antecedent verbal stimulus. Participants repeated “say,” or repeated the entire phrase, “Ved. Say, Dop” instead of just echoing “Dop.” Similar types of faulty echoic behavior have been observed with children with ASD during early intensive behavioral intervention (Esch, 2008; Kodak et al., 2012; Valentino et al., 2012). Also, some participants did not respond until vocal prompts were provided across many sessions of training. This pattern of behavior has been observed in previous studies when the response requirements were unclear (e.g., Pilgrim et al., 2000) or participants had a history of prompt dependence (e.g., Gorgan & Kodak, 2019). Finally, we often observed that participants engaged in echoic and self-echoic behavior during inter-trial intervals and between sessions. For example, after engaging in an error and receiving a vocal prompt (“Ved. Say, Dop”), participants sometimes echoed the correct response repeatedly (“Dop, Dop, Dop, Dop”) until the next trial began a few seconds later.

The consistency in errors made by undergraduate students and children with ASD replicates previous research that shows both typically developing children and children with ASD engage in similar errors when initially responding to questions that require control by more than one stimulus component (Sundberg & Sundberg, 2011). Due to the prevalence of consistent error patterns in children with and without ASD and undergraduate students, it is possible that certain patterns of errors prior to skill acquisition are to be expected. Examination of these error patterns can help behavior analysts determine the sources of control for responding during instruction. Then, if error patterns persist during training, procedures could be modified so that responding comes under the control of all necessary stimuli. For example, Grow et al. discontinued training with the simple-conditional method and programmed conditional-only discrimination

training with procedural modifications to resolve persistent error patterns. The procedures in the current investigation did not require modification, as all participants eventually stopped making errors during trials as their responses came under the programmed sources of stimulus control.

It is certainly possible that some individuals with ASD may perform more poorly on tasks like multiply controlled tacts (Sundberg & Sundberg, 2011) due to their delayed verbal behavior repertoires. Because the comparison of training procedures in the present investigation did not show that either method produced persistent faulty stimulus control, this comparison could be replicated with children with ASD who have clinical goals related to acquisition of multiply controlled tacts. Replicating the current comparison with children with ASD will help identify whether the procedures are efficacious and efficient with this population as well as permit an examination of error patterns during training.

Results of our posttest showed that high levels of correct independent responses occurred for all listener responses (exemplars and categorical responses). However, limited emergence occurred in the categorical speaker skills (simple category tacts, compound category tacts, and intraverbal behavior) across participants. The low levels of correct responses during posttests for speaker relations may have occurred because the participants were never directly taught nor required to say the category names. Although the antecedent verbal stimulus in each trial helped establish multiply controlled tacts (i.e., responses under the control of a verbal and nonverbal stimulus), training did not appear sufficient to teach two responses per stimulus (e.g., the exemplar tact and category tact).

Therefore, the antecedent verbal stimulus may have facilitated the emergence that we observed, although it did not help to establish all relevant relations.

Previous researchers have suggested that creating a learning history in which the participant is required to respond to stimuli as a speaker and a listener can increase efficacy of intervention and promote emergence of other relations (Horne & Lowe, 1996; Miguel, 2016; Wu et al., 2019). This may also be the case for all components of the trial (i.e., exemplar and category tacts). Future researchers could have participants echo the antecedent verbal stimulus (i.e., category name) prior to providing a tact of the exemplar. If participants are required to engage in a vocal response of the category (not just the exemplars) at some point during training, this could help facilitate emergence to speaker responses in the posttest.

Some limitations of the present investigation should be noted. First, our results suggest that the stimuli from set 2 were acquired in fewer training sessions than set 1 for six of seven participants, regardless of condition assignment. Although the difference in efficiency was minimal between conditions, our results suggest that there was something about the training set 2 stimuli that made them easier to acquire. Future researchers should consider different stimuli and stimulus combinations in their investigations of this topic.

Second, it is possible that acquisition in one of the conditions carried over to, or influenced, the results of the other condition (Barlow & Hayes, 1979). The multiple control established in one training procedure could have resulted in multiple control in another condition that would not have this outcome if trained in isolation. Previous researchers have suggested that establishing conditional control during conditional

discrimination training can result in rapid acquisition of subsequent conditional discriminations (Saunders & Spradlin, 1989; 1990). Future research could investigate the current trial arrangements in alternative single subject or group experimental designs.

Finally, the present study was translational, and our participant demographic was selected due to the novelty of the research question and limited research on this topic (Baer, 1973). The type of multiply controlled tacts investigated in the present study are not skills that would be taught to early learners with ASD who do not have a history of learning other complex verbal behavior. Thus, we would anticipate that individuals with ASD who receive this type of intervention in the future would have acquired similar putative prerequisite skills (i.e., bi-directional naming repertoires; Miguel, 2016; Miguel 2018). Nevertheless, to fully understand the behavioral mechanisms responsible for emergence of intraverbal-tacts following training, the procedures of the present investigation should be replicated with children with ASD, other populations, and varied age ranges.

Ultimately, we hope that the results of the present investigation can be further studied and subsequently applied to verbal behavior training for children with ASD, developmental disabilities, and/or other populations. We also hope the results will lead to systematic lines of research on stimuli and procedures to include in conditional discrimination and verbal behavior training.

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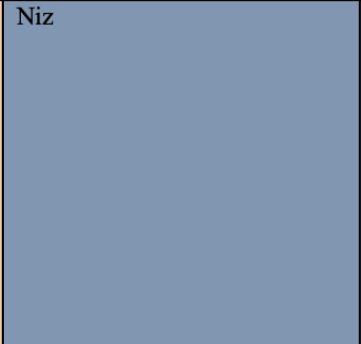
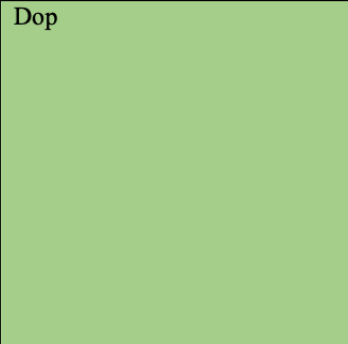
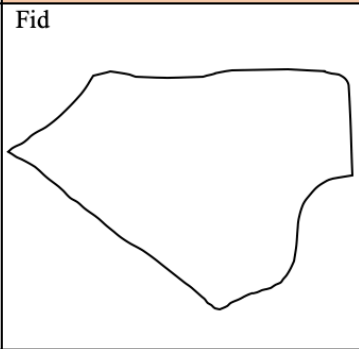
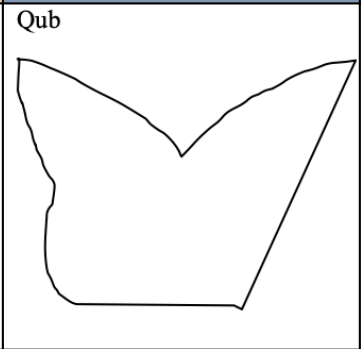
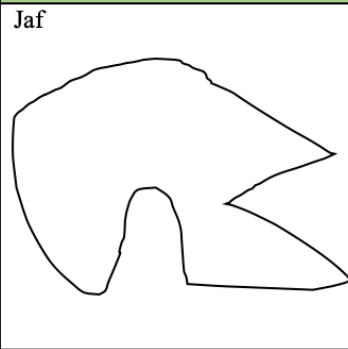
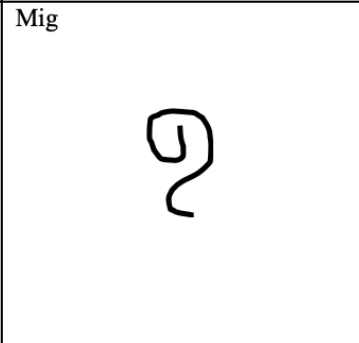
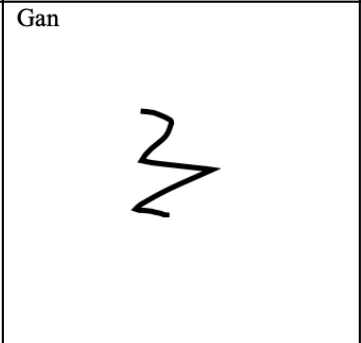
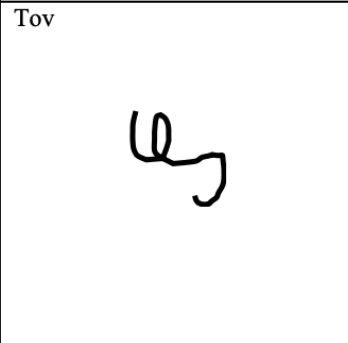
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APPENDICES

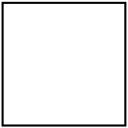
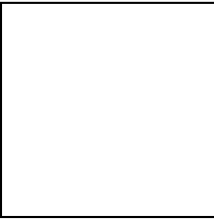
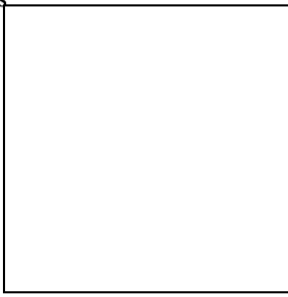






Appendix A

Simple Stimuli and the Assigned Component and Category Tacts For One Group of Stimuli (Set 1)

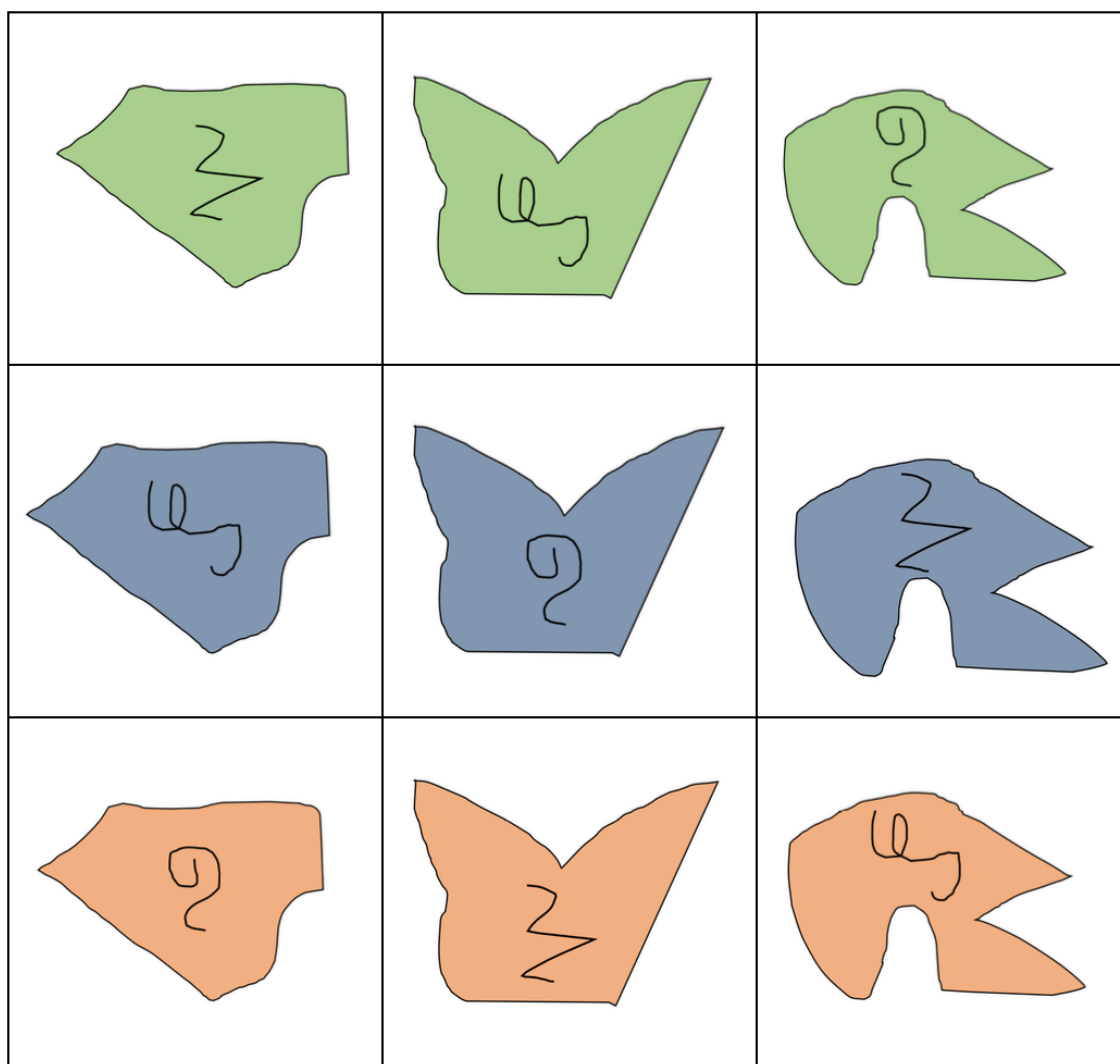
Color (Ved)	Kas 	Niz 	Dop 
Shape (Pog)	Fid 	Qub 	Jaf 
Symbol (Ral)	Mig 	Gan 	Tov 

Appendix B

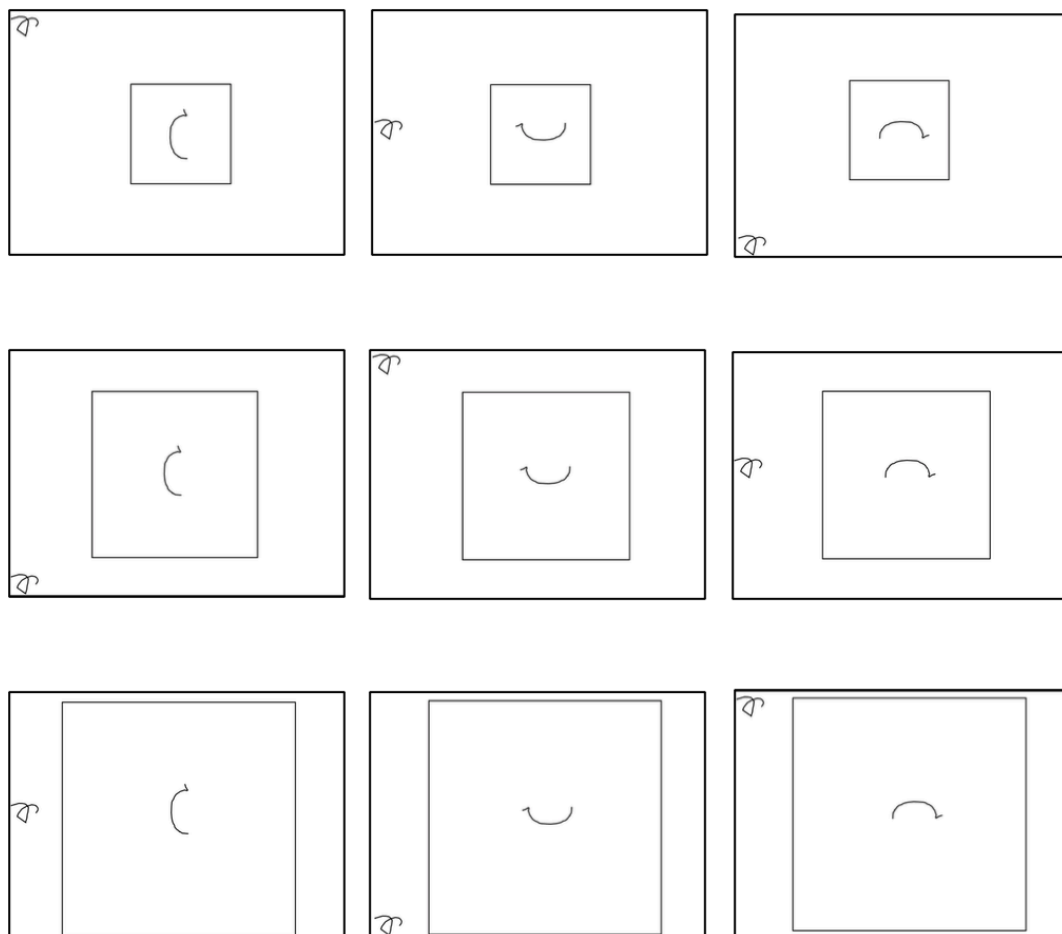
Simple Stimuli and the Assigned Component and Category Tacts For the Second Stimulus Group (Set 2)

<u>Size (Yat)</u>	Nuf 	Reg 	Bis 
<u>Orientation of symbol (Jud)</u>	Dem 	Sov 	Hic 
<u>Placement of symbol in overall square (Tef)</u>	Vob 	Pav 	Jit 

Appendix C
9 Exemplars of Compound Stimuli (Set 1)

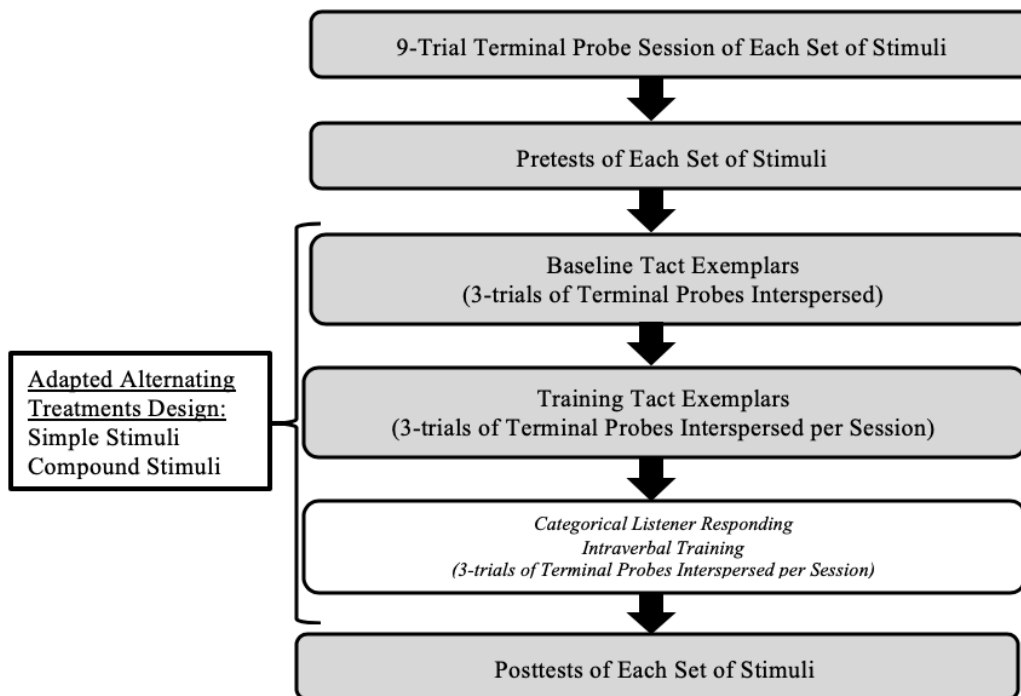


Appendix D
9 Exemplars of Compound Stimuli (Set 2)



Appendix E

Sequence of Experiment Procedures



Note. White phase indicates that training did not need to occur for this component.

Appendix F

#	Skill	Definitions	Procedures
2	Categorical auditory-visual conditional discriminations	Touching the target stimulus in a three-comparison array within 5 s of the S ^D that matched the category component of the S ^D	<p><u>Simple:</u></p> <ol style="list-style-type: none"> 1. A three-stimulus array presented horizontally on the table in each trial 2. Simple stimuli placed in a three-card horizontal array in front of the participant on the table consisting of one stimulus from each category (e.g., one shape, one color, and one symbol). 3. Experimenter presented the auditory sample stimulus of the category (e.g., “Touch Ved”) and waited 5 s for the participant to engage in a response 4. Prompts and reinforcement provided in training but not baseline <p><u>Compound:</u></p> <ol style="list-style-type: none"> 1. Same as the simple condition, except the use of compound stimuli on each trial 2. The visual sample stimulus had one overlapping feature with each of the compound comparisons in the array 3. Discriminative stimulus was “Match (category)”
3	Intarverbal Training	Saying the three vocal responses that correspond to the antecedent verbal stimulus (e.g., participant says “Dop, Kas, Niz” when the antecedent verbal stimulus is “Ved”)	<ol style="list-style-type: none"> 1. During each trial, the experimenter said one of the categories (e.g., “Ral”) and allowed 5 s for the participant to engage in an intraverbal response comprised of the three exemplars of that category (e.g., “Mig, Gan, Tov”) 2. Prompts and reinforcement provided in training but not baseline

Appendix G

Explanations of probes of other relations in the pretests and posttest. Three trials of each of these relations were conducted in this order.

	Stimulus Type	Skill	Explanation
Speaker Responses	Simple	Categorical Tacts	The experimenter held up a card of one component without presenting a vocal S ^D and allowed 5 s for a response of the category. If participants tacted the exemplar, they were asked, “anything else”.
	Compound	Categorical Tacts	The experimenter held up a compound stimulus, ensured attending to a relevant component by pointing to it, and allowed 5 s for a response of the category. If participants tacted the exemplar, they were asked, “anything else”.
	N/A	Pure Intraverbals (1 item)	The experimenter provided the AVS (i.e., each component individually) and allowed 5 s for the participant to engage in a correct intraverbal response of the category.
Listener Skills	Simple	Exemplar AVCD (3-card array)	Three components, one from each category were laid on the table in a horizontal array. The experimenter provided the S ^D (“touch [exemplar name]”) and allowed 5 s for a selection response consisting of touching the one stimulus that corresponds with the S ^D .
	Compound	Exemplar AVCD (1-card array)	On each trial, one compound stimulus was laid on the table. The experimenter provided the S ^D (“touch [exemplar name]”) and allowed 5 s for a selection response consisting of pointing the component within the compound stimulus that corresponds with the S ^D .
	Simple	Categorical AVCD (array of all)	All nine components from the condition were laid on the table in a messy array. The experimenter provided the S ^D (“touch [category name]”) and allowed 5 s for a selection response consisting of touching all stimuli (3) that correspond with the S ^D . If participants got 1 correct, they were asked, “anything else” or “any others”.
	Compound	Categorical AVCD (1-card array)	On each trial, one compound stimulus was laid on the table. The experimenter provided the S ^D (“touch [category name]”) and allowed 5 s for a selection response consisting of pointing the component within the compound stimulus that corresponds with the S ^D .
	Compound	Categorical AVCD (9-card array)	Nine compound stimuli were laid on the table in a messy array. The experimenter provided the S ^D (“touch [category name]”) and allowed 5 s for a selection response consisting of pointing to all stimulus components that correspond with the S ^D . If participants got 1 correct, they were asked, “anything else” or “any others”.